INSULATING MATERIAL

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Technical Field and Industrial Applicability of The Invention

The present invention relates generally to the field of acoustical and thermal insulation and, more particularly, to a unique new insulating material of low-melt and high-melt bicomponent fibers exhibiting a unique blend of structural and acoustical insulating properties.

Background of the Invention

Acoustical and thermal liners for application to vehicles are well known in the art. These liners typically rely upon both sound absorption, i.e. the ability to absorb incident sound waves and transmission loss, i.e. the ability to reflect incident sound waves, in order to provide sound attenuation. They also rely upon thermal shielding properties to prevent or reduce the transmission of heat from various heat sources (e.g. engine, transmission and exhaust system), to the passenger compartment of the vehicle. Such insulation is commonly employed as a hoodliner, dash liner and firewall liner. More recently, such liners have been employed on engine covers so as to attenuate the sound of the engine closer to its source.

Examples of acoustical and thermal insulation in the form of liners are disclosed in a number of prior art patents including U.S. Patents 4,851,283 to Holtrop et al. and 6,008,149 to Copperwheat. As should be apparent from a review of these two patents, engineers have generally found it necessary to construct such liners from a laminate incorporating (a) one or more layers to provide the desired acoustical and thermal insulating properties and (b) one or more additional layers to provide the desire mechanical strength properties which allow simple and convenient installation as well as proper functional performance over a long service life.

While a number of adhesives, adhesive webs and binding fibers have been specifically developed over the years to secure the various layers of the laminates together, laminated liners and insulators have an inherent risk of delamination and failure. The potential is, in fact, significant mainly due to the harsh operating environment to which such liners and insulators are subjected. Many liners and insulators are located near and/or are designed to shield high heat sources such as the engine, transmission and components of the exhaust system. As a result, the liners and insulators are often subjected to temperatures in excess of 200°F which have a tendency to degrade the adhesives or binders over time.

Additionally, many liners and insulators are subjected to water from the surface of the roadways which has a tendency to be drawn by capillary action into the interface between the layers of the liner or insulator. Such water may have a deleterious affect upon the integrity of the adhesive layer over time. This is particularly true when that water includes in solution salt or other chemicals from the roadway which are corrosive and destructive.

A need is therefore identified for a hood, dash, firewall or engine cover liner incorporating a nonlaminate acoustical and thermal insulating layer of polymer fibers which avoids any inherent potential for delamination. Such a liner is suitable for use in the high temperature operating environment of the engine compartment and capable of providing the desired mechanical strength and rigidity for ease of installation as well as the desired acoustical and thermal insulating properties.

Summary of the Invention

Accordingly, the present invention relates to an insulating material exhibiting a unique combination of acoustical insulating and strength/ structural properties. The insulating material comprises in weight percent from about 20-60% low melt bicomponent fiber, 10-40% high melt bicomponent fiber and 20-60% staple fiber. The melt includes an average fiber diameter of between about 10-30 microns, more typically 16-24 microns and most typically 18-22 microns. The material has a density of between about 1.0-10.0 pcf and a flexural strength of between about 40-1200 psi. Still more specifically describing the invention, the insulating material has the acoustical absorption coefficients as follows: 0.17-0.24 at a

frequency of 500 Hz, 0.29-0.63 at a frequency of 1000 Hz, 0.50-0.94 at a frequency of 2000 Hz and 0.71-0.99 at a frequency of 4000 Hz all at 2 pcf density.

Still further describing the invention, the insulating material has a thermal conductivity value of between about 0.20 and 0.30 at 2 pcf density. The staple or bulking fibers are selected from a group of materials consisting of polyester fibers, polyethylene fibers, polypropylene fibers, nylon fibers, rayon fibers, glass fibers, natural fibers and mixtures thereof.

The low melt bicomponent fibers are selected from a group of materials consisting of copolyester/polyethylene terephthalate (CoPET/PET), poly 1,4 cyclohexanedimethyl terephthalate/polyethylene terephthalate (PCT/PET), poly 1,4 cyclohexanedimethyl terephthalate/ polypropylene (PCT/PP), glycol-modified polyethylene terephthalate/ polyethylene terephthalate (PETG/PET), propylene/polyethylene terephthalate (PP/PET), nylon 6/nylon 66, polyethylene/glass, or other combinations of polymers including polymer/glass and polymer/natural fiber that yield differential melt flow temperatures. The bicomponent fibers may be any of a variety of configurations that yield acceptable fiber binding such as sheath-core, side-by-side, segmented pie, etc. The low melt bicomponent fibers are described as having a melt flow temperature of about 100 to 130°C.

The high melt bicomponent fibers are selected from a group of materials consisting of copolyester/polyethylene terephthalate (CoPET/PET), poly 1,4 cyclohexanedimethyl terephthalate/polyethylene terephthalate (PCT/PET), poly 1,4 cyclohexanedimethyl terephthalate/ polypropylene (PCT/PP), glycol-modified polyethylene terephthalate/ polyethylene terephthalate (PETG/PET), propylene/polyethylene terephthalate (PP/PET), nylon 6/nylon 66, or other combinations of polymers that yield differential melt flow temperatures. The bicomponent fibers may be any of a variety of configurations that yield acceptable fiber binding such as sheath-core, side-by-side, splitable segmented pie, etc. The high melt bicomponent is described as having a melt flow temperature of about 170-200°C. Bicomponent fibers described as crystalline or semi-crystalline which have a melt flow temperature of generally about 150 to 180°C may be substituted in part or whole for the high melt bicomponent

fiber.

Brief Description of the Drawing

The accompanying drawing incorporated in and forming a part of the specification, illustrates several aspects of the present invention, and together with the description serves to explain the principles of the invention. In the drawing:

Figure 1 is a schematical side elevational view of one possible embodiment of the present invention;

Figures 2-4 are schematical side elevational illustrations of other possible alternative embodiments of the present invention;

Figure 5 is a graphical illustration comparing the flexural strength in the machine direction of the structural/acoustical insulating material of the present invention with a standard state of the art polymer formulation; and

Figure 6 is a graphical illustration comparing the flexural strength in the cross machine direction of the structural/acoustical insulating material of the present invention with a standard state of the art polymer formulation.

Reference will now be made in detail to the present preferred embodiment of the invention, an example of which is illustrated in the accompanying drawing.

Detailed Description of the Invention

The present invention relates to an insulating material that is particularly noteworthy for its combination of structural and acoustical properties. Specifically, as described below the insulating material yields at least a 100% improvement in elastic modulus over a standard polymer formulation while (1) maintaining equivalent acoustics to the standard formulation, (2) yielding high temperature performance and (3) having a minimal cost upcharge over standard formulations. While in the past it has generally been found necessary to give up a significant level of acoustical performance or utilize much higher priced fibers or both to gain improvement in structural properties, the present invention achieves the dramatic increase in elastic modulus without compromising acoustical properties or low production costs and as such represents a significant advance in the art.

The insulating material of the present invention comprises in weight percent from about 20-60% low melt bicomponent fiber, 10-40% high melt bicomponent fiber and 20-60% staple fiber. The melt includes an average fiber diameter of between about 10-30 microns, or typically 16-24 microns and most typically 18-22 microns. The material has a density of between about 1.0-10.0 pcf and a flexural strength of between about 40-1200 psi.

For purposes of clarity, the bicomponent fibers are comprised of a principal polymer component and a binder polymer component. The bicomponent fibers may be formed as sheath-core fibers with the principal polymer component forming the core material and the binder polymer component forming the sheath around the core. It should be understood, however, that other arrangements may be utilized such as a side-by-side arrangement. In any such arrangement, the binder polymer component binds the bicomponent fibers and the staple fibers to themselves and to each other.

The binder polymer component of the bicomponent fibers has a softening point lower than the softening point of the principal polymer component so that the two materials respond differently upon heating. When heated to a temperature above the softening point of the binder polymer component but below the softening temperature of the principal polymer component, the binder component softens and becomes sticky, thereby bonding the various bicomponent fibers where they are in contact with each other and the staple fibers. As long as the temperature is not raised as high as the softening point of the principal polymer component, that component remains in the form of fibers.

The low melt bicomponent fibers are selected from a group of materials consisting of copolyester/polyethylene terephthalate (CoPET/PET), poly 1,4 cyclohexanedimethyl terephthalate/polyethylene terephthalate (PCT/PET), poly 1,4 cyclohexanedimethyl terephthalate/ polypropylene (PCT/PP), glycol-modified polyethylene terephthalate/ polyethylene terephthalate (PETG/PET), propylene/polyethylene terephthalate (PP/PET), nylon 6/nylon 66, polyethylene/glass, or other combinations of polymers including polymer/glass and polymer/natural fiber that yield differential melt flow temperatures. The bicomponent fibers may be any of a variety of configurations that yield acceptable fiber binding

such as sheath-core, side-by-side, segmented pie, etc. The low melt bicomponent fibers are described as having a melt flow temperature of about 100 to 130°C.

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The insulating material provides unique acoustical insulating properties in combination with the flexural strength of between about 40-1200 psi. Specifically, the insulating material is characterized by acoustical absorption coefficients of 0.17-0.24 at a frequency of 500 Hz, 0.29-0.63 at a frequency of 1000 Hz, 0.50-0.94 at a frequency of 2000 Hz and 0.71-0.99 at a frequency of 4000 Hz all at 2 pcf density. The insulating material also has a thermal conductivity value of between about 0.20 and 0.30 at 2 pcf density. Accordingly, it should be appreciated that the insulating material also provides good thermal insulating properties in conjunction with good acoustical insulating and structural properties.

The staple or bulking fibers utilized in the insulating material are selected from a group of materials consisting of polyester fibers, polyethylene fibers, polypropylene fibers, nylon fibers, rayon fibers, glass fibers, natural fibers and mixtures thereof.

The insulating material of the present invention may be utilized for a number of applications requiring the unique structural, acoustical insulating and, when appropriate for certain applications, thermal insulating properties

of the present invention. For example, the insulating material of the present invention may be utilized in the construction of hood, dash, firewall or engine cover liners such as shown in Figures 1-4 of the present invention.

The liner 10 shown in Figure 1 comprises an acoustical and thermal insulating layer 12 of the insulating material of the present invention. More specifically, a single, nonlaminated layer 12 is provided with the necessary mechanical strength and rigidity to allow easy installation and the desired acoustical and thermal insulating properties. Advantageously, all of these benefits are achieved in a light weight liner 10 which may even be used in compact vehicles where fuel economy concerns lead manufacturers to seek weight savings wherever possible.

In a first alternative embodiment shown in Figure 2, the liner 10 also comprises a single, nonlaminated acoustical and thermal insulating layer 12 of the insulating material of the present invention. The layer 12 includes a relatively high density, nonlaminate or unitary skin 14 of that insulating material along at least one face thereof. The formation of the relatively high density, nonlaminate skin 14 of polymer fiber may be completed in accordance with the process described in detail in co-pending U.S. Patent Application Serial No. 09/607,478, entitled "Process For Forming A Multi-Layer, Multi-Density Composite Insulator", filed June 30, 2000 (Owens Corning Case Nos. 24811 and 24812). The full disclosure of this document is incorporated herein by reference.

Advantageously, the high density skin 14 will not delaminate from the layer 12 under the environmental conditions existing in the engine compartment and also adds structural integrity and strength to the liner 10 which aids significantly in handling and fitting the part during installation. The high density skin 14 is also more aesthetically pleasing. Still further, for many applications the high density skin 14 eliminates the need to provide an additional facing layer of another type of fabric material. This serves to virtually eliminate any potential for failure of the lining due to delamination. It also results in a liner 10 made exclusively of one material that is, therefore, fully recyclable.

Further, since the skin may be formed with a hot platen during the molding of the liner 10 to its desired shape, no additional processing step is required. This reduces production costs relative to a liner with a fabric or

other facing since such a facing must be adhere to the acoustical and thermal insulating layer in a separate processing step.

In yet another embodiment shown in Figure 3, the liner 10 includes a single, nonlaminated acoustical and thermal insulating layer 12 of the insulating material of the present invention in combination with a facing layer 16 over a first face 18 of the acoustical and thermal insulating layer. The facing layer 16 may be constructed from a polymer material selected from a group consisting of polyester, rayon, polyethylene, polypropylene, ethylene vinyl acetate, polyvinyl chloride and mixtures thereof.

In yet another alternative embodiment shown in Figure 4, the liner 10 comprises a single, nonlaminated acoustical and thermal insulating layer 12 of the insulating material of the present invention as described above in combination with a first facing layer 16 covering a first face 18 thereof and a second facing layer 20 covering a second, opposite face 22 thereof. The second facing layer 20 may be constructed from the same or a different material as the first facing layer 16. Preferably the first and second facing layers have a weight of between about 0.50 - 3.00 ounces per square yard.

In accordance with yet another aspect of the present invention, the acoustical and thermal insulating layer 12 may be a natural white or include any appropriate form of coloring or pigment in order to provide a gray or black color. Alternatively, the acoustical and thermal insulating layer 12 may incorporate any appropriate color or pigment so as to substantially approximate the color of the first and/or second facing layers 16, 20 and/or the paint color of the vehicle. This provides significant aesthetic benefits. Specifically, when the liner 10 is molded under heat and pressure in order to nest with the hood, firewall or other appropriate body panel or superstructure of the engine compartment, the liner 10 is often subjected to deep drawing at one or more points. This deep drawing has a tendency to spread the weave of the fabric facing 16, 20 thereby exposing a portion of the underlying face 18, 20 of the acoustical and thermal insulating layer to light. If the acoustical and thermal insulating layer 12 does not substantially match the color of the facing layer 16, 20 this creates an undesirable color variation in these deep drawn areas. In contrast, by matching the color of the layer 12 with the facings 16, 20, this color variation may be substantially eliminated.

It should further be appreciated that during use the facing layer 16, 20 may become snagged or subjected to a partial tear exposing some of the face of the underlying acoustical and thermal insulating layer 12. Once again, by matching the color of the layer 12 with the facing 16, 20, any color variation is substantially eliminated and one's attention is not as readily drawn to the damaged area. Accordingly, an overall improved aesthetic appearance is maintained over the service life of the liner 10.

The insulating material of the present invention is produced in accordance with processing steps generally known in the art.

The fibers need to be blended in the given ratios and thermally bonded to form a semi-rigid blanket. The fibers generally are packaged in 500 - 700 lb. bales. Each of the three fibers is generally baled separately although it is possible to get the fibers from the fiber supplier blended in the proper ratio and baled together. For purposes of this description, it is assumed that the fibers come baled separately. Generally each baled fiber needs to be "opened" by a bale opening system common in the industry. The opening system fluffs up the fiber and sends the appropriate amount of fiber by weight to a blending area. This fluffing serves to decouple the clustered fibrous masses and enhances fiber-to-fiber contact. The blending area distributes the different fibers uniformly according to the desired fiber ratios.

Once blended the fibers are uniformly distributed on a conveying system forming an unbonded "sheet" or "blanket" of uniformly distributed fibers. Thermally activated powdered binders or other supplemental binding methods may be added during the fiber blending or conveying stages prior to the sheet entering the thermal bonding oven. The oven is constructed to allow heated air to penetrate the fibrous pack and bring the fibers to a temperature sufficient to activate the binding fibers and/or other binding materials. If the blanket material is being produced for post molding applications, the oven temperature need only be high enough to activate at least some of the low melt binding fibers. The post mold operation only needs to reach temperatures high enough to activate the higher melt fibers. If no post mold operation is to occur then the oven needs to be set to a temperature high enough to activate both the low melt and high melt fibers - in this case the required temperature would be at least

180°C. Once the fibers have reached the appropriate temperature the oven or post oven area should be capable of reducing the temperature below the activation point of the binding materials, in this case approximately below 100°C. The desired thickness of the blanket is generally established in the oven process. After exiting the oven, additional binding materials such as powders can be added to the fibrous blanket or other treatments such as densifying one or both surfaces of the blanket can occur.

The blanket can now be handled and utilized "as is" for structural-acoustical applications or it can be post molded to produce parts of simple or highly complex shapes. Molding methods can vary among those typically used in the industry for molding of thermoplastic materials. One such method is to preheat the blanket material to a sufficient temperature to (re)activate all of the binding materials and then quickly transfer the heated blanket to a cold molding tool and press mold the part until the temperature of the fibers are below the activation point of the low melt binding fibers.

In the case of the samples used for structural testing in the following example, no post molding operation was utilized to achieve the desired test thickness.

The following examples are presented to further illustrate the invention, but it is not to be considered as limited thereto.

Example

The structural/acoustical formulation for the insulating material of the present invention was tested and compared to a standard formulation of 40% low melt bicomponent having an average fiber diameter of 14.3 microns, 30% staple (bulking) fiber having an average fiber diameter of 12.4 microns and 30% staple (bulking) fiber having an average fiber diameter of 50.0 microns. Together, the standard formulation had an average fiber diameter of 30.0 microns. Flexural strength testing of the structural/acoustical formulation of the insulating material of the present invention and the standard formulation was then run in accordance with ASTM D1037 static three point bend. The results of this testing are clearly illustrated in Figures 5 and 6. Figure 5 shows the flexural strength of the two formulations in the machine direction and Figure 6 shows the flexural strength of the two formulation in the cross-machine direction. In both instances, it should be appreciated that the structural/acoustical formulation

of the insulating material of the present invention provides at least a 100% improvement in elastic modulus over the standard formulation tested.

The structural/acoustical formulation of the insulating material of the present invention also provides acoustical absorption coefficients somewhat better than those provided by the standard formulation and as such, provides significant gains in strength and enhanced acoustical insulating performance. As such, the present invention represents a significant advance in the art.

In summary, numerous benefits result from employing the concepts of the present invention. An insulating material providing a unique combination of structural strength, acoustical insulating and even thermal insulating properties is provided. The insulating material is particularly suited for use as a hood, dash, firewall or engine cover liner. It provides the mechanical strength and rigidity to allow ease in handling and installation while also providing thermal and acoustical insulating properties that are consistently and reliably maintained over a long service life even in the high temperature and high moisture operating environment of the engine compartment. Such performance characteristics have heretofore been unavailable in a liner incorporating a single, nonlaminated layer of acoustical and thermal insulating material.

The foregoing description of a preferred embodiment of the invention has been presented for purposes of illustration and description. It is not intended to be exhaustive or to limit the invention to the precise form disclosed.

The embodiment was chosen and described to provide the best illustration of the principles of the invention and its practical application to thereby enable one of ordinary skill in the art to utilize the invention in various embodiments and with various modifications as are suited to the particular use contemplated. For example, crystalline/semicrystalline bicomponent fibers having a melt flow temperature of about 150°C to about 180°C may be substituted in whole or in part for the high melt bicomponent fiber. All such modifications and variations are within the scope of the invention as determined by the appended claims when interpreted in accordance with the breadth to which they are fairly, legally and equitably entitled.